ECOSYSTEM STABILITY AND BIOPHYSICAL LAND CLASSIFICATION TECHNIQUES

George McKibbon

Department of Urban and Regional Planning
Ryerson Polytechnical Institute
Toronto, Ontario

OCCASIONAL PAPER NO. 7
September 1981

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ECOSYSTEM STABILITY AND BIOPHYSICAL LAND CLASSIFICATION TECHNIQUES

A. INTRODUCTION

The purpose of this paper is to examine the concept of landscape stability. Assuming that ecosystem stability (steady state) is a proper objective for land use planning, how would one reconstitute environmental data in a land classification which would achieve this end? This issue has emerged from personal planning experience and the experience of others involved in environmental planning. Of note, is the following statement by E.B. Wilken:

> If the effects of urbanization on ecosystems are not well understood, then man's security and integration with the ecological cycle remains infirm.[1]

While man is a dominant ecological force, human settlements remain dependent on an ecological balance for existence.[2]

Biophysical land classification traditionally has been oriented towards the rural hinterland.[3] In the late 1960's, the movement to classify Canada's soils for suitability reached momentum. Land capability classification was seen as a tool to enable efficient orderly development.[4] It has been, and still is, viewed as a means of breaking new ground in the rural hinterland. Only recently has concern for an urban classification occurred. This urban interest has been principally oriented towards the conversion of rural land to urban uses. While Dorney sees the potential emerging for a classification from the urban core to the rural hinterland, the innovation still rests on the notion of the classification being geared principally to use, to production.[5]

The rural/urban continuum envisaged by Dorney is to complete the urban classification theories proposed by the Chicago geographer, Park. It includes a range of land uses or classes, stretching from the urban core to the wilderness found in the hinterland. All are connected spatially by this continuum of land.[6] Can land uses be aggregated in this way? Can we take human activity patterns and view them meaningfully in this way? A growing body of evidence suggests that socio-economic systems operate within an ecological context which poses real limits to continued land use expressions which irreparably change the nature of environmental inter-relationships.

Implicit in the notion of land capability mapping is the fitting of land uses to the land. The possibilities are endless and the planner is left with making decisions as to which uses are appropriate for the lands under study. Conversely an emerging concept in environmental planning suggests that certain lands need to be set aside in a natural state. The function of these lands is to absorb the side effects of urban and regional development and to maintain a functioning ecological system intact.[7] Eugene Odum suggests that in a region with one or more industrial sites, 50% of the land and surface waters should remain in a natural state.[8] The Forrester[9]-Meadows[10] models suggest that the oceans, all large water bodies and 4 to 5 acres of natural or semi-natural land per person needs to be kept in good working order as tertiary treatment systems, if the quality of urban industrial areas is to be maintained and improved.

Odum postulates that environmental awareness reflects that, for the first time in it's history, humanity faces ultimate as opposed to local limits to human aspirations.[11] William Ophuls in restating Garrett Hardin's parable of the Tragedy of the Commons notes as follows:

> ...the tragic logic of the commons is sustained by three premises: a limited commons, cattle that need ample grazing room to prevent the commons from becoming "bare worn", and a rational self-seeking herdsman. If any one of these premises is removed, the tragedy is averted. As we have already seen, the Great Frontier (the New World) in fact effectively removed, the first premise for nearly 4000 years.[12]

The homesteading era has come to an end. There are no remaining new worlds to be occupied. What then constitutes the nature of the limits which are emerging in the Commons?

Odum provides five basic points which assist us in answering this question:

1. In a technological advanced industrial society, energy itself is not likely to be limiting, but the consequences of converting energy from one form to another is limiting.

2. There is no technological way to bypass the 2nd law of thermodynamics which states that as energy is used a proportion is converted or dispersed in an unusable (by man) state; energy cannot be recycled as can materials.

3. Exponential growth cannot continue for very long.

4. As the size of a system increases, the cost of maintenance of the network increases.

5. The natural environment, the life support system for both man and his energy-consuming machines, is the major means for tertiary treatment.[13]

These factors taken in total require planners, as practitioners of land use, to reconstitute our view of the land. Land classification as presently practised, views land as constituting an opportunity for certain land uses. Odum's five points require planners to add a dimension to this view. Landscape is an expression of natural processes. These natural processes are impinged upon by human activity systems. Consequently, the opportunities offered by a parcel of land may change or be removed because of our failure to recognize and live within limits imposed by ecological processes.

Consider, for example, Odum's fifth point. Generally in Ontario, aquatic ecosystems have suffered most in terms of water quality deterioration and changes in drainage characteristics from the effects of land use and, in particular, changing land use. The conclusion has been made in several studies that the release of leachate from septic tank systems to water bodies has been a considerable factor in this overall deterioration.

The introduction of leachate to water bodies can result in many changes. Principally, however, added nutrients result in accelerated plant growth, plant die-off and decomposition, and greater oxygen demand. Diverse ecosystems in which many individual species exist are replaced by simplified ecosystems where many individuals of a few limited species are found.

Gradually, over time, the input of nutrients (leachate) to water bodies results in the inducement of change in the dynamics of the receiving aquatic ecosystem. These changes may become self-perpetuating so that any return to a natural condition or stable state requires additional planned interventions into the aquatic ecosystem.[14]

Sewage system setbacks from water bodies are intended to provide greater soil assimilation of nutrients before treated leachate reaches the adjacent water body. The set back requirement has become a conventional means of overcoming this potential problem of water quality deterioration arising out of settlement adjacent to streams, lakes and rivers.

What dimensions should be used for this setback? Where surface water bodies exist, exchanges of water between the surface and the ground water table occurs. Lands adjacent to a water body are influenced by this interchange particularly during the wetter conditions of the year when the ground water table may approach the ground surface. During these conditions, exchanges in leachate between the sewage system ground water table and the water body can readily occur if proper spacing or buffering isn't provided.[15]

Likewise, where ravines or steep banks exist adjacent to a water body, the measurement of the setback needs to consider the slopes. The intent is to deal with the bank condition during freeze thaw conditions. Such slopes often become saturated during this condition which in combination with the bank gradient results in leachate moving freely into the water body at the base.

Many planning jurisdictions have adopted the concept of a sewage system setback from water bodies. The following discussion of these setbacks will provide a framework for the consideration of a separation distance from water bodies in the light of Odum's fifth point.

B. SEPARATION DISTANCES: UTILIZING THE NATURAL ENVIRONMENT AS A MEANS OF TERTIARY TREATMENT

The Province of Ontario has adopted a 50 foot setback in most situations. This 50 foot setback is considered by the Ministry of the Environment to be a minimum setback distance. As such, it is meant to apply to optimum conditions such as flat land, well drained soils, absence of flooding and/or sensitive water bodies, etc. Site specific and area wide conditions, however, may require increases in these minimum separation distances. The following examples are an indication of the kinds of revisions to this minimum setback distance which have been used.[16]

In the administrative northeastern region of the Ministry of the Environment, a formula for the calculation of phosphorus emissions to lakes from shoreline development has been established.[17] This formula can be used for not only predicting phosphorus related impacts from existing development, but also for assessing proposed development and providing for proper development siting. Phosphorus is one of the keys to nutrient change in these lakes and consequent deterioration in fishing and recreation potential. The following quote shows the connection between phosphorus emission to lakes and separation distances:

> ....our Region has defined all property beyond 150 feet of a surface water body as having no phosphorus impact on water quality as far as sewage disposal is concerned. Hence lots beyond 150 feet from the water do not affect the available reserve capacity, so they should be evaluated as a non-water front property.[18]

In Galway Township (Peterborough, Ontario), the Ministry of the Environment prepared a report detailing the water quality status of Crystal Lake in relation to shoreline development.[19] The intent was to apply an understanding of the Lake's water quality status to land development standards. The report revealed that water quality remained good although in a precarious position. Any increase in pollutants would trigger substantial change in this threshold condition. The following setback was recommended to deal with this condition:

> New proposed development should be planned on the basis of a 100 foot setback of septic tank and tile field systems from the lakeshore and inflows. As parts of the shoreline with steep slopes offer no retention of nutrients from the tile bed system, the upper edge of these slopes where land levels off should be considered the start of the 100 foot setback distance.[20]

> In assessing the impact of a proposed cottage development adjacent to Pencil Lake in Cavendish Township, Peterborough County, the impact of phosphorus loadings on Pencil Lake was assessed. While it was established that there would be a small change in water quality, the 'sensitive nature of the lake" was justification for a 100 foot separation distance between septic systems and the lakeshore.[21]

Again in Peterborough County, the Ministry of the Environment assisted the Seven Links Planning Board in carrying out a report which defined the water quality status of major lakes in the planning area, provided some indication of shoreline development sensitivity and provided guidelines to the Planning Board to assist in making decisions on proposed shoreline development.[22] The report classified 17 lakes into three classes of sensitivity based primarily on water quality analysis.

On the least sensitive lakes, water quality had generally deteriorated and no additional restrictions were applied. When moderate sensitivity was determined, careful siting of septic systems was recommended. On the most sensitive lakes, the following recommendations were made:

> .....new proposed development should be planned on the basis of a 100 foot setback of septic tank and tile field systems from the shoreline. As parts of some lake shorelines with steep slopes offer no retention of nutrients from tile bed systems, the upper edge of these slopes where land levels off should be considered the start of the 100 foot setback distance.
>
> .....clearing of the vegetation on lots during development especially between the tilebed site and the shoreline should be minimized.[23]

Where significant fisheries exist in the southeastern region, (M.O.E.) a Lakes Survey Program was initiated in 1975 to assist land use planners in assessing water quality and fisheries implications of shoreline development proposals.[24] During the study, 52 lakes were divided into three categories of development sensitivity to possible oxygen depletion resulting from shoreline development. For each category, development recommendations, as follows, were made:

> Highly Sensitive Lake Trout Waters
>
> (ii) permits issued by the appropriate Health Unit for a private waste disposal system be made conditional upon the system being located 100 feet from the shoreline of the lake or otherwise as remote from the shoreline as the lot will permit.
>
> (v) the property between the shoreline of the lake and the dwelling or private waste disposal system should be retained in it's natural state to serve as a buffer to assist in minimizing the land-surface transport of nutirents to the lake.

Moderately Sensitive Lake Trout Waters

(i) The approval of any new lot with shoreline frontage.... should be conditional upon the structure and associated waste disposal systems not being closer than 100 feet from the shoreline of the lake.

(ii) It is recommended that the title for any new lot with shoreline frontage have a suitable condition inserted which would prohibit any distrubance of the natural soil mantle and provide protection against removal of the mature tree cover within 100 feet of the shoreline of the lake.[25]

In each of the above situations, where existing lots are concerned and the 100 foot separation distance cannot be achieved, it is recommended that the separation distance should be as far from the shoreline as is practical. Where feasible the setback should be at least 100 feet.

The Hamilton-Wentworth Region has recognized the importance of separation distances in the severance policies of the draft Regional Official Plan.[26] The following policy has been recommended:

7) No portion of a dwelling or tile bed is to be permitted within a distance of 60 metres (200 feet) from any stream, natural watercourse or pond, or 15 meters (50 feet) from a regional floodline whichever is the greater distance and all parcels of land shall be located accordingly.[27]

The Simcoe-Georgian Area Task Force assessed water quality in the Simcoe-Georgian Area Development Strategy Study.[28] The report assumes that, wherever possible, development should not be located so close to the shorelines of Georgian Bay, Lake Simcoe, or the streams tributary to these waterbodies that runoff will be harmful to water quality:

As a general rule, this will mean 300' from lake fronts and 100' from streams. These figures, of course, will be higher or lower depending on local conditions. We have also assumed that care will be taken when constructing housing developments so that there will not be large runoffs or silt or sand into the streams, which might result in a fish kill or destruction of the environment required for fish spawning.[29]

The Prince Edward Island Land Commission took a slightly different approach in dealing with a water body buffer.[30] In the report entitled Concept Plan: A Framework for Future Development in the North Central Region of Prince Edward Island, the concern was principally the impact of erosion and pollutants on the inshore fisheries of the North Sea. The report recommended the following with respect to water courses:

> Watercourse and Wetland Buffers (Minimum 60-135 feet)
>
> Construction, farming and forestry close to the water's edge lead to flood damage, loss of land and buildings by stream erosion and loss of amenity value. Wetland buffer strips could be designed to allow for activity use while minimizing harmful side effects of sewage, runoff, erosion and sedimentation.[31]

The Macon County (Illinois) Natural Capabilities Study and Land Use Plan[32,33] attempts to establish land uses which will not exceed the natural carrying capabilities of the County. A number of associated water oriented buffers were discussed in the report and land use plan. A 300 foot buffer strip around a proposed reservoir was established to protect this municipal water source from erosion/siltation and leachate from septic systems. Likewise a 35 foot buffer was established from the edge of floodplains while a 40 foot minimum setback is recommended along drainage ways. Where a floodplain is involved, the combined buffer in most cases would exceed 100 feet. In addition, the width will vary depending on the land profile and water-course size. Septic tanks are to be eliminated around the tributary streams.

In the manual, Planning for Wildlife in Cities and Suburbs (published by the U.S. Department of the Interior),[34] a setback is established although not for leachate purposes. This buffer is to deal with the fostering of terrestrial and aquatic wildlife:

> It has been suggested that on watersheds, filterstrips bordering tributaries in flat terrain should be 50 feet wide, with an increase of four feet for each percent of slope. This guideline may be useful in determining the width of vegetation desirable for erosion control along streams.[35]

The State of Rhode Island has several comments to make on septic systems and their impact on adjacent water bodies. The following comments are excerpted from the State of Rhode Island Costal Resources Management Program:[36]

> Nitrates released into the ground below the rock system have been found to travel more than 200 feet through the soil.
>
> The existing 50 foot setback for all septic systems from open bodies of water required by the Department of Health is insufficient in many soil types to prevent the release of nutrients.
>
> Septic systems that meet all state standards and that are in good working condition can therefore release nutrients into coastal waters
>
> Failing septic systems pose an additional hazard due to the release of pathogens as well as nutrients.[37]

No specific setback is recommended. A permit procedure is established in which the following recommended factors are to be considered:

> the ability of soil types present throughout the leaching area to remove pollutants,
>
> the degree and direction of slope in the leaching area, flood hazards,
>
> depth to and fluctuation of the water table,
>
> depth to bedrock,
>
> the presence of filled land,
>
> and the density of housing.[38]

John Clark[39] in his planning guidelines for coastal ecosystems suggests the following comments on coastal areas and septic systems:

> Septic systems installed above the floodplain level need only follow general standards, except on steeply rising shores where precautions are required to prevent leaching of wastes into coastal waters. As a general rule, tanks and drain fields are to be set back a minimum 150 feet from the upper flood plain boundary to prevent biological oxygen demand and nutrient pollution of coastal waters.

Recommended Constraints:

1. Septic tanks are not to be used in coastal floodplain areas.

2. A minimum setback of 150 feet from the upper floodplain boundary is recommended for septic tanks.

3. Existing systems are to be improved or replaced where necessary to function optimaly, regular cleaning is to be enforced.[40]

In the Sanibel Report,[41] Clark goes on to say:

> L. B. Leopold, a U.S. Geological Survey hydrology report, has reached the following conclusions:
>
> 1. ...for soil cleansing to be effective, contaminated water must move through unsaturated soil at least 100 feet.
>
> 2. ...no source of pollution such as a seepage field (should be) closer than 300 feet to a channel or watercourse. Leopold added that even this setback does not prevent dissolved materials such as nitrates form enriching the water, thus potentially creating a biotic intolerance through eutrophication.
>
> In a coastal area, a setback of 300 feet would be a safe starting point, unless soil and ground water conditions are particularly unsuited for nitrate removal in which case an even greater distance should be considered.[42]

The shoreline Restructions Section of the Adirondack Park Land Use and Development Plan,[43] (located in New York State) states as follows:

> In the case of all lakes, ponds, rivers and streams, the minimum setback of any on-site sewage drainage field or seepage pit shall be 100 feet from the mean high water mark in all land use areas.[44]

This setback includes streams in the consideration of septic tank systems. Many of the previous examples dealt with large water bodies.

What conclusions can be drawn from this survey of planning reports and documents dealing with septic tank and tile field separation distances from water bodies? It becomes evident that there is a coalescence of environmental sensitivities in this critical distance. The Ontario Ministry of the Environment reports also note the importance of maintaining tree and ground vegetation cover within the buffer. Likewise the Prince Edward Island Land Commission does not distinguish between a buffer for pollutants as opposed to the impact of erosion. In wildlife planning for urban areas, the U.S. Department of the Interior establishes a setback for wildlife purposes which is quite consistent with those established for septic and erosion control.

Given the clustering of environmental sensitivities into certain discrete components of the landscape, it should be possible to differentiate those lands within a study area which are essential to ecosystem stability. In addition, in those lands not so classified, it should be possible to identify performance standards which, if adhered to, should maintain environmental processes at acceptable quality levels. This re-orientation of land classification is recommended as a means by which land use planners can address the objective of ecosystem stability.

Several land use plans in recent years have attempted to achieve an integrated approach to the environment in order that some issue(s) of ecosystem stability sould be achieved. The following review of those plans is intended to highlight the approaches and to suggest some practical measures which could be followed in other planning exercises.

C THE APPLICATION OF LAND USE PLANS AS AN INTEGRATED APPROACH TO ECOSYSTEM STABILITY

1. A Policy For Resource Management of the Eastern Slopes in The Province of Alberta

The Resource Management Policies for the Eastern Slopes of the Rocky Mountains in the Province of Alberta deal with a area of roughly 35,000 square miles.[45] These lands offer a wealth of renewable and non-renewable resources. However, this resource base is not unlimited. Concerns have been raised over land use conflicts, environmental quality and the important watershed characteristics of these lands. Hence the Province of Alberta has prepared this comprehensive plan for management and development.

These Management Policies utilize a form of zoning applied at the regional level only. Each zone identifies broad land units for the purposes of management and use. Detailed plans within the zones are to be prepared on a priority basis. Each zone is based on an evaluation of the physical environment, existing resources, present land use, demand and public interest. Zoning provides direction for future management, and identifies permitted and restricted uses.

A number of general priorities and guidelines for the future management of these lands have been identified. These are listed as follows:

> Decisions for development of the Eastern Slopes and management of its resources are based on a comprehensive, integrated planning system .
>
> The highest priority is placed on watershed management to ensure a reliable supply of clean water for acquatic habitats and downstream users.
>
> The recreation potential and aesthetic quality of the mountains and foothills will be maintained, while increasing the opportunities of Albertans for enjoyment of this unique region.
>
> Critical wildlife habitat will be protected to maintain those species presently found in the Eastern Slopes.
>
> Selected areas of natural significance that are unique or representative will be protected.
>
> The resources of the Eastern Slopes will be utilized and developed, consistent with principles of conservation and environmental protection.
>
> The management of renewable resources is the long term priority of resource management in the Eastern Slopes. Non-renewable resource development will be encouraged where it is not in conflict with the long term goal of renewable resource management.
>
> Service centre development will generally be directed to defined nodes associated with transportation corridors.
>
> Crown lands in the Eastern Slopes will be retained in public ownership for the use of all Albertans. In registered subdivisions, the sale of small parcels of public land may be considered.[46]

The principal ecological role of the Eastern Slopes is viewed as a hydrological water producing area. Management is geared to a high level of watershed production. It is intended to maintain natural stream flows and water quality. The management of water is viewed in terms of quality, timing and quantity. The emphasis arising out of this management is to maintain natural stream flow conditions. On the other hand, land development issues exist. For instance this region contains

undeveloped coal reserves. The boundaries of the coal reserves do not conform to the landscape features or the zones which are based principally on these features. The zoning can be adjusted for the purposes of coal exploration and development.

Basically, there exists three broad classes of land zones. These include Protection, Resource Management and Development classes. These three basic categories are subdivided into the following zones:

Protection	1. Prime Protection 2. Critical Wildlife
Resource Management	3. Special Use 4. General Recreation 5. Multiple Use 6. Agriculture
Development	7. Industrial 8. Facility

Permitted and restricted uses are established for each zone. These are depicted in a tabular format in Table 1.

Each zone is based on the physical and biological properties of the land as moderated by scientific and non-scientific perception and resource needs. Within the Protection class, two zones exist. The intent of the Prime Protection Zone is to preserve environmentally sensitive terrain and valuable aesthetic resources. These lands comprise rugged mountain scenery and the areas of highest precipitation. Watershed protection is of paramount concern. The Critical Wildlife Zone manages the unique and important wildlife subregions. By virtue of the many combinations of climate, topography and vegetation, these lands provide suitable habitat for many wildlife populations. These lands consist of ranges or habitats such as key winter ranges, migration routes and calving areas critical to the survival of wildlife populations.

TABLE 1: PERMITTED ACTIVITIES BY LAND USE ZONES

ACTIVITY \ ZONES	1 Prime Protection	2 Critical Wild Life	3 Special Use	4 General Recreation	5 Multiple Use	6 Agriculture	7 Industrial	8 Facility
Non-Mechanical Recreation	/	/	R	/	/	/	R	/
Fishing	/	/	R	/	/	/	R	/
Hunting	/	/	R	R	/	/	R	X
Trails (Non-motorized)	R	R	R	/	/	/	R	/
Off Highway Vehicle Activity	X	R	R	R	/	/	/	/
Primitive Camping	R	R	R	/	/	/	X	X
Serviced Camping	X	X	R	/	/	R	X	/
Intensive Recreation	R	X	R	/	/	X	X	/
Scientific Study	/	R	R	R	/	/	/	/
Trapping	/	R	R	R	/	/	X	X
Logging	X	R	R	R	/	/	/	X
Cultivation	X	X	R	X	R	/	X	R
Domestic Grazing	X	R	R	X	/	/	X	R
Petroleum & Natural Gas Exploration and Development	X	R	R	X	/	/	/	R
Mineral Exploration and Development	X	X	R	X	/	/	/	X
Coal Exploration and Development	X	R	R	R	/	/	/	X
Transportation and Utility Corridors	R	R	R	R	/	/	/	/
Commercial Development	X	X	R	R	R	R	X	/
Industrial Development	X	X	R	X	/	R	/	R
Residential	X	X	R	X	R	/	R	/

/ Permitted Uses - Uses that will be allowed under normal guidelines and land use regulations.
X Not Permitted - Uses that are not compatible with the intent or capabilities of a land use zone.
R Restricted - Uses that may be compatible under certain circumstances and stricter than normal controls.

Alberta Energy and Natural Resources, A Policy for Resource Management of the Eastern Slopes (pg. 7)

The Resource Management class comprises four separate zones. The Special Use Zone deals with lands of unique management requirements which cannot be accommodated in other zones. Examples of these management requirements include research areas. The General Recreation Zone includes lands required to ensure a variety of natural environments suitable for outdoor recreation. A wide range of dispersed and concentrated outdoor activities will be provided for in a natural setting. Management is geared to the natural environment and to improving recreation opportunities. The Multiple Use Zone covers broad areas of forested foothills with a variety of natural resources. These lands were experiencing growing pressures for public land dispositions and resource development. This Zone comprises approximately 65% of the Eastern Slopes exclusive of National Parks. The goal of the zone is to provide for a full range of resource utilization within a multi-use context. Planning for particular uses will be based on land capability and integrated management planning. Small areas are to be disturbed at any one point in time. Examples include areas to be used for forest production while providing for watershed production. Emphasis will also be geared to sustained yield. Lastly, the Agricultural Zone includes lands presently utilized or considered suitable for cultivation. These lands include improved grazing lands and are found principally along the eastern boundary of the region . This zone has been defined using soil capability, existing land use patterns and land ownership.

The Development class of zones includes two zones. The Industrial Zone includes existing and approved industrial operations. These include coal mines, gas processing plants, and cement plants. The size of the zone will be restricted to that which is practically required to support the proposed development. The very nature of the zone precludes other uses. Infrastructure and transportation facilities are intended to be important components in the planning of these uses. Proposals

for new Industrial Zones will require detailed environmental, social and economic review. The Facility Zone includes existing and potential urban and commercial development as well as lands designated to support facilities for outdoor recreation.

Zone boundaries are intended to be flexible and can be changed based on the evaluation of site specific data. During the detailed planning for uses in each zone, the needs for possible changes can be identified. This zoning mechanism provides the means by which applications for the disposition of public lands are processed and evaluated in the Eastern Slopes. This evaluation process is based on the best available knowledge of the environment. Continued monitoring will provide additional information.

2. The Sanibel Plan: Sanibel Islands, State of Florida

The Sanibel Plan[47] was devised by the Sanibel Planning Commission for the Island of Sanibel off the coast of Florida. This Plan is intended to provide for the long term conservation of the natural resources of the Island while providing for urban and suburban growth. The Plan attempts to achieve the following ends:

1) set a future limit on population consistent with natural limits, notably those imposed by water resources and by the imperative of evacuation before hurricanes;

2) distribute the permitted number of new structures (about 2,000) over the developable land in accordance with the carrying capacity of the natural systems;

3) establish a strong set of performance standards for all developments;

4) develop a scientific plan for restoration of past ecological damage (particularly to the water systems); and

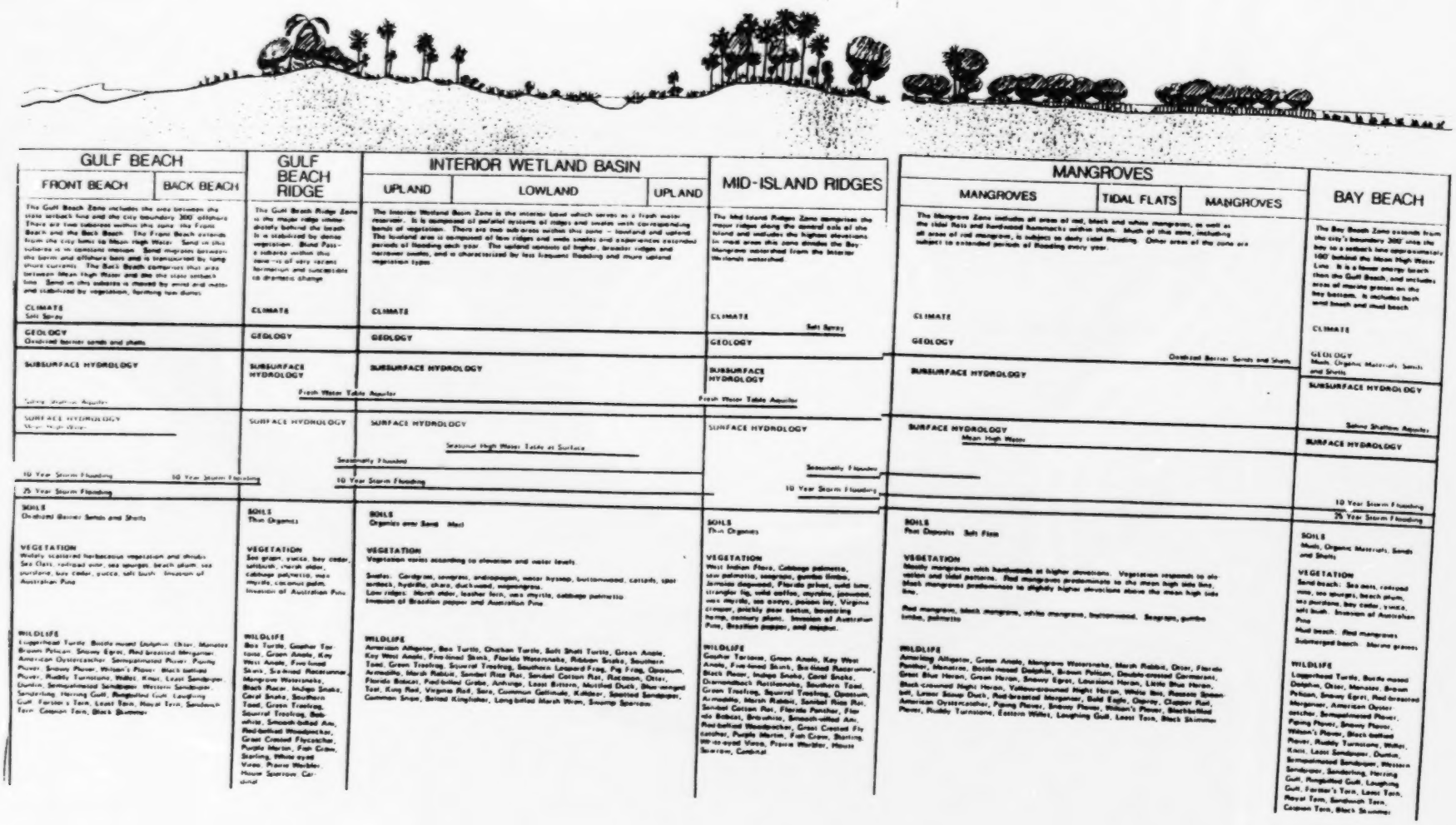
5) provide for the highest level of continuing public participation.[48]

The Sanibel Plan deals principally with natural systems. Work leading to plan formation focussed on identifying carrying capacities. Natural constraints to development were noted as being unusually high. These natural constraints include vulnerability to hurricane damage, highly permeable soils unsuitable to septic tanks and mangrove swamps and interior wetlands covering approximately 45% of the land surface. The inventory of the island ecosystem made a special effort to consider natural processes. The planning program which resulted from the effort was geared to maximum protection and perpetuation of the natural systems. This was achieved by dealing with basic water systems which transcend the island's physical land forms and biotic communities.

In identifying and classifying the subsystems of the island's ecosystem, ecological zones were established. These zones constituted tangible expressions of the natural processes which operate on the island. Zones were identified and refined during the data collection and analysis phases. In the Plan, these zones are the basis for permitted uses, density limits and performance standards. Early in the inventory process it was realized that management and protection of the Sanibel environment depends primarily on proper water management. Hence restoring and conserving the natural system depends primarily on water management.

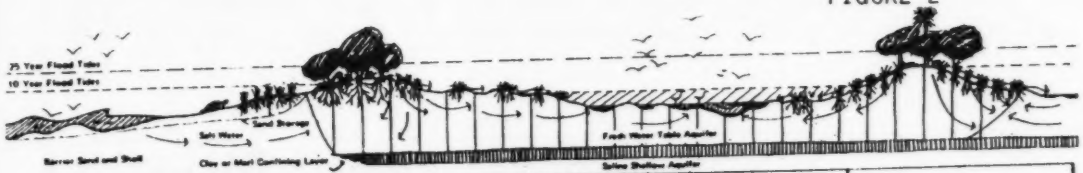
Figure 1, 2, 3 and 4 provide an overview of the movement from the inventory of the island's subsystems to an analysis of the function of each identified zone. Management guidelines on a per zone basis are then established. The zones, in turn, become the basis for permitted uses which in turn are governed by the development intensities. Each zone has a separate set of performance standards to be met by the permitted uses. These standards vary depending on the zone and are based principally on the management guidelines.

FIGURE 1



Sanibel's Major Ecological Zones As Interpreted by Wallace, McHarg, Roberts and Todd.
Source: Clark T., The Sanibel Report, The Conservation Foundation, 1976.

FIGURE 2



GULF BEACH

FRONT BEACH

The Gulf Beach Zone includes the area between the state setback line and the city boundary 300' offshore. There are two subareas within this zone - the Front Beach and the Back Beach. The Front Beach extends from the city limit to Mean High Water. Sand in this subarea is in constant motion. Sand migrates between the berm and off shore bars and is transported by longshore currents. The Back Beach comprises that area between Mean High Water and the state setback line. Sand in this subarea is moved by wind and water and stabilized by vegetation forming low dunes.

FUNCTIONS
Storm Protection
Shoreline Stabilization
Maintenance of Marine Life
Maintenance of Wildlife

The Gulf Beach Zone is the Island's first defense in storm and flood when the impact of storm waves erodes the sand reservoir on the berm. The low dunes of the Back Beach are a reservoir of sand which may be eroded after the berm in a severe storm, thus protecting property further inland on the Beach Ridge. The natural profile of the Gulf Beach Zone is a response to processes of wind, currents, and waves. Undisturbed, it is in a state of balance with natural forces, thus "stabilizing" the shoreline. The Front Beach supports the marine life for which Sanibel is famous, and is an important feeding area for island wildlife. The low dunes of the Back Beach are an important nesting area for wildlife, the loggerhead turtle being a prime example.

ELEMENTS ESSENTIAL TO FUNCTIONS

Storm Protection and Shoreline Stabilization
- Natural profile of beach
- Sand reservoir in berm, bars and dunes
- Gradual and dispersed runoff from land
- Longshore sand movement
- Hardy dune vegetation

Maintenance of Marine Life
- Access to beach
- Good water quality

Maintenance of Island Wildlife
- Access to beach
- Good water quality
- Abundant marine life

BACK BEACH

The Gulf Beach Zone is the Island's first defense in storm and flood when the impact of storm waves erodes the sand reservoir on the berm. The low dunes of the Back Beach are a reservoir of sand which may be eroded after the berm in a severe storm, thus protecting property further inland on the Beach Ridge. The natural profile of the Gulf Beach Zone is a response to processes of wind, currents, and waves. Undisturbed, it is in a state of balance with natural forces, thus "stabilizing" the shoreline. The Front Beach supports the marine life for which Sanibel is famous, and is an important feeding area for island wildlife. The low dunes of the Back Beach are an important nesting area for wildlife, the loggerhead turtle being a prime example.

ELEMENTS ESSENTIAL TO FUNCTIONS

Storm Protection and Shoreline Stabilization
- Natural profile of beach
- Sand reservoir in berm, bars and dunes
- Gradual and dispersed runoff from land
- Longshore sand movement
- Hardy dune vegetation

Maintenance of Marine Life
- Access to beach
- Good water quality

Maintenance of Island Wildlife
- Access to beach
- Good water quality
- Abundant marine life

GULF BEACH RIDGE

The Gulf Beach Ridge Zone is the major ridge immediately behind the beach. It is stabilized by dense vegetation. Blind Pass - a subzone within this zone is of very recent formation and susceptible to dramatic change.

FUNCTIONS
Storm Protection
Flood Protection
Shoreline Stabilization
Maintenance of Water Quality
Maintenance of Fresh Water System

The Gulf Beach Ridge is a dike which buffers flood tides and storm winds, prevents increased flooding in the interior (unless overtopped by waves) and contributes to shoreline stabilization. Water quality is maintained by the filtering function of soil and vegetation. Much fresh water runoff enters the ground in the Gulf Beach Ridge Zone, halting inward intrusion of salt water from the Gulf and thus maintaining the extent of the fresh water lens.

ELEMENTS ESSENTIAL TO FUNCTIONS

Storm Protection and Shoreline Stabilization:
- Shoreline stabilization and storm protection functions of the Gulf Beach Zone
- Natural configuration and elevation of ridge
- well established hardy vegetation

Maintenance of Water Quality
- Gradual and dispersed runoff
- Filtration of runoff through vegetation and soil

Maintenance of Fresh Water System:
- Recharge of runoff to fresh water lens
- Drainage of runoff to interior wetland
- Aquifuge between shallow saline aquifer and fresh water lens

INTERIOR WETLAND BASIN

UPLAND

The Interior Wetland Basin Zone is the interior basin which serves as a fresh water reservoir. It is composed of parallel systems of ridges and swales with corresponding bands of vegetation. There are two sub areas within this zone - lowland and upland. The lowland area is composed of low ridges and wide swales and experiences extended periods of flooding each year. The upland consists of higher, broader ridges and narrower swales, and is characterized by less frequent flooding and more upland vegetation types.

FUNCTIONS
Flood Protection
Maintenance of Water Quality
Maintenance of Fresh Water System
Maintenance of Island Wildlife

Since the elevation of the Interior Wetland Basin is lower than the adjacent zones, it serves as a storage area for flood waters until they are absorbed into the aquifer. Water Quality is protected by the filtering function of soil and vegetation. This zone is crucial to the maintenance of the fresh water lens. It also has the capacity to maintain and improve water quality, and provides food, shelter, water, and nesting areas to wildlife, including the American alligator.

ELEMENTS ESSENTIAL TO FUNCTIONS

Flood Protection:
- Water storage capacity
- Free flowing water circulation

Maintenance of Water Quality
- Free flowing water circulation
- Gradual and dispersed runoff
- Filtration of runoff through vegetation and soil
- Restriction of industrial and domestic wastes discharged into interior wetland
- Water quality function of Gulf Beach Ridge and Mid-Island Ridges Zones

Maintenance of Fresh Water System
- Recharge of runoff to fresh water lens
- Sufficient water levels
- Aquifuge between shallow saline aquifer and fresh water lens
- Free flowing water circulation

Maintenance of Wildlife
- Good water quality
- Fresh water system
- Access to water
- Native vegetation of value to wildlife

LOWLAND

UPLAND

MID-ISLAND RIDGES

The Mid-Island Ridges Zone comprises the major ridges along the central axis of the Island and includes the highest elevations. In most areas this zone divides the Bay-Mangrove watershed from the Interior Wetlands watershed.

FUNCTIONS
Storm Protection
Flood Protection
Maintenance of Water Quality
Maintenance of Fresh Water System

The elevation of the Mid-Island Ridges Zone provides flood protection. This zone helps maintain water quality by the filtering functions of soil and vegetation. Much fresh water runoff enters the ground in the Mid-Island Ridges Zone, halting inward intrusion of salt water from the Bay and thus maintaining the fresh water lens.

ELEMENTS ESSENTIAL TO FUNCTIONS

Flood Protection:
- Elevation of ridge

Maintenance of Water Quality:
- Gradual and dispersed runoff
- Filtration of runoff through vegetation and soil

Maintenance of Fresh Water System:
- Recharge of runoff to fresh water lens
- Drainage of runoff to interior wetland
- Aquifuge between shallow saline aquifer and fresh water lens
- Elevation of ridge

MANGROVES

MANGROVES

The Mangrove Zone includes all areas of red, black and white mangroves, as well as the tidal flats and hardwood hammocks within them. Much of this zone, including all areas of red mangrove, is subject to daily tidal flooding. Other areas of the zone are subject to extended periods of flooding every year.

FUNCTIONS
Storm Protection
Flood Protection
Shoreline Stabilization
Maintenance of Water Quality
Maintenance of Marine Life
Maintenance of Wildlife

The dense canopy and roots of the mangroves buffer storm winds and tidal surges. The arching prop-roots of the red mangrove and the roots of the black mangrove trap sediments and stabilize and extend the shoreline. Mangroves preserve water quality by filtering suspended material and assimilating dissolved nutrients. Mangroves maintain the highly productive marine ecosystem and provide food, shelter, and nesting areas for wildlife.

ELEMENTS ESSENTIAL TO FUNCTIONS

Storm Protection, Shoreline Stabilization and Land Building:
- Healthy mangroves

Maintenance of Water Quality:
- Healthy mangroves
- Restriction of domestic and industrial wastes discharged into Mangrove Zone
- Water circulation

Maintenance of Marine Life
- Healthy mangroves
- Good water quality

Maintenance of Island Wildlife
- Healthy mangroves
- Abundant marine life

TIDAL FLATS

MANGROVES

BAY BEACH

The Bay Beach Zone extends from the city's boundary 300 into the bay to a setback line approximately 100' behind the Mean High Water Line. It is a lower energy beach than the Gulf Beach, and includes areas of marine grasses on the bay bottom. It includes both sand beach and mud beach.

FUNCTIONS
Storm Protection
Shoreline Stabilization
Maintenance of Marine Life
Maintenance of Wildlife

The Bay Beach Zone buffers the impact of storm waves. The natural form of the Bay Beach is a response to natural processes of wind, currents, and waves. Undisturbed, it is in a state of balance with natural forces, thus "stabilizing" the shoreline. The Bay Beach is a feeding area for island wildlife. Beds of marine grasses on submerged portions of the beach are important nursery and feeding areas for marine life.

ELEMENTS ESSENTIAL TO FUNCTIONS

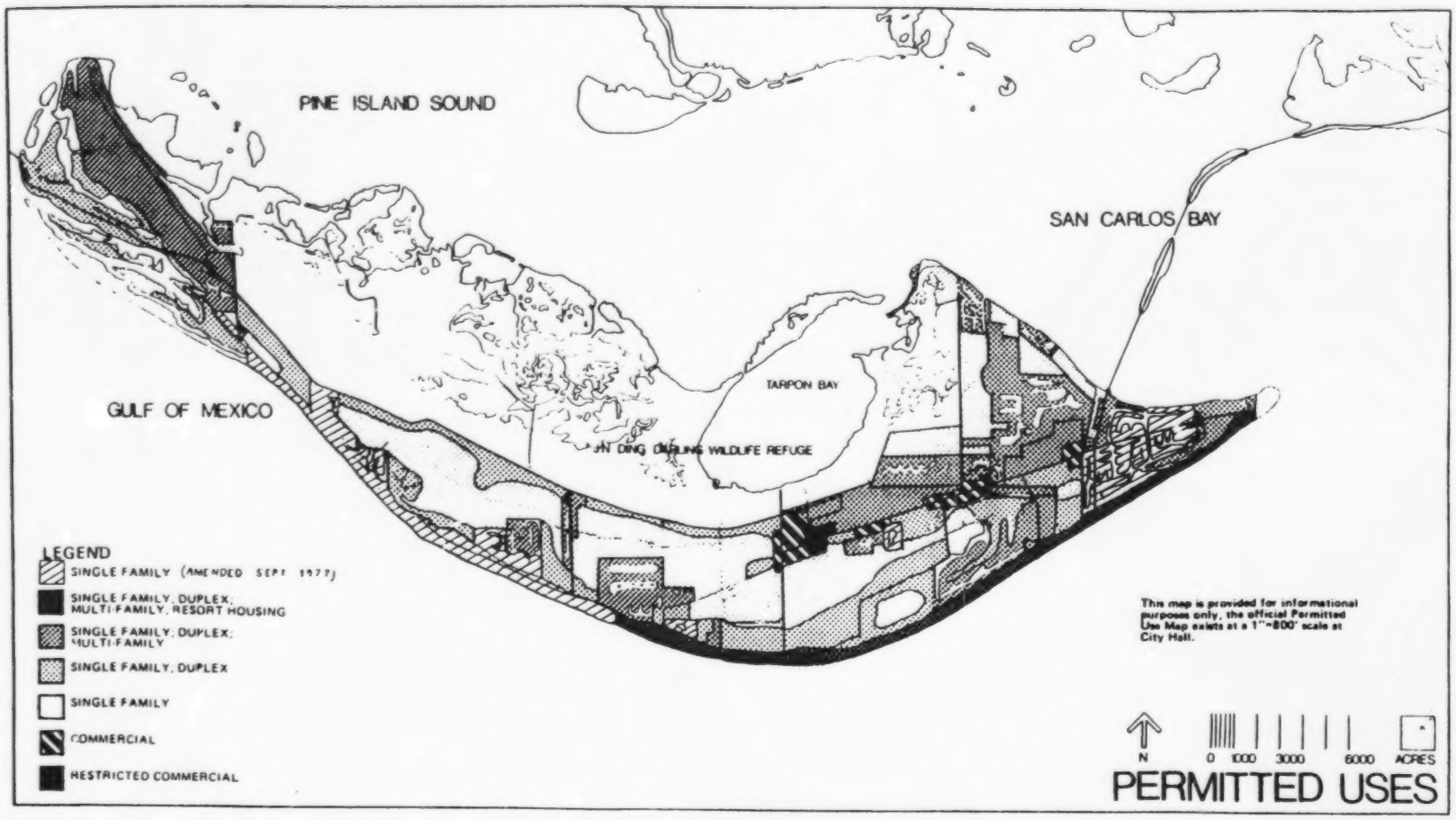
Storm Protection and Shoreline Stabilization
- Natural profile of beach
- Gradual and dispersed runoff from land
- Longshore sand movement
- Hardy beach vegetation

Maintenance of Marine Life
- Mangroves
- Marine grass beds
- Access to beach
- Good water quality

Maintenance of Wildlife
- Access to beach
- Good water quality
- Abundant marine life

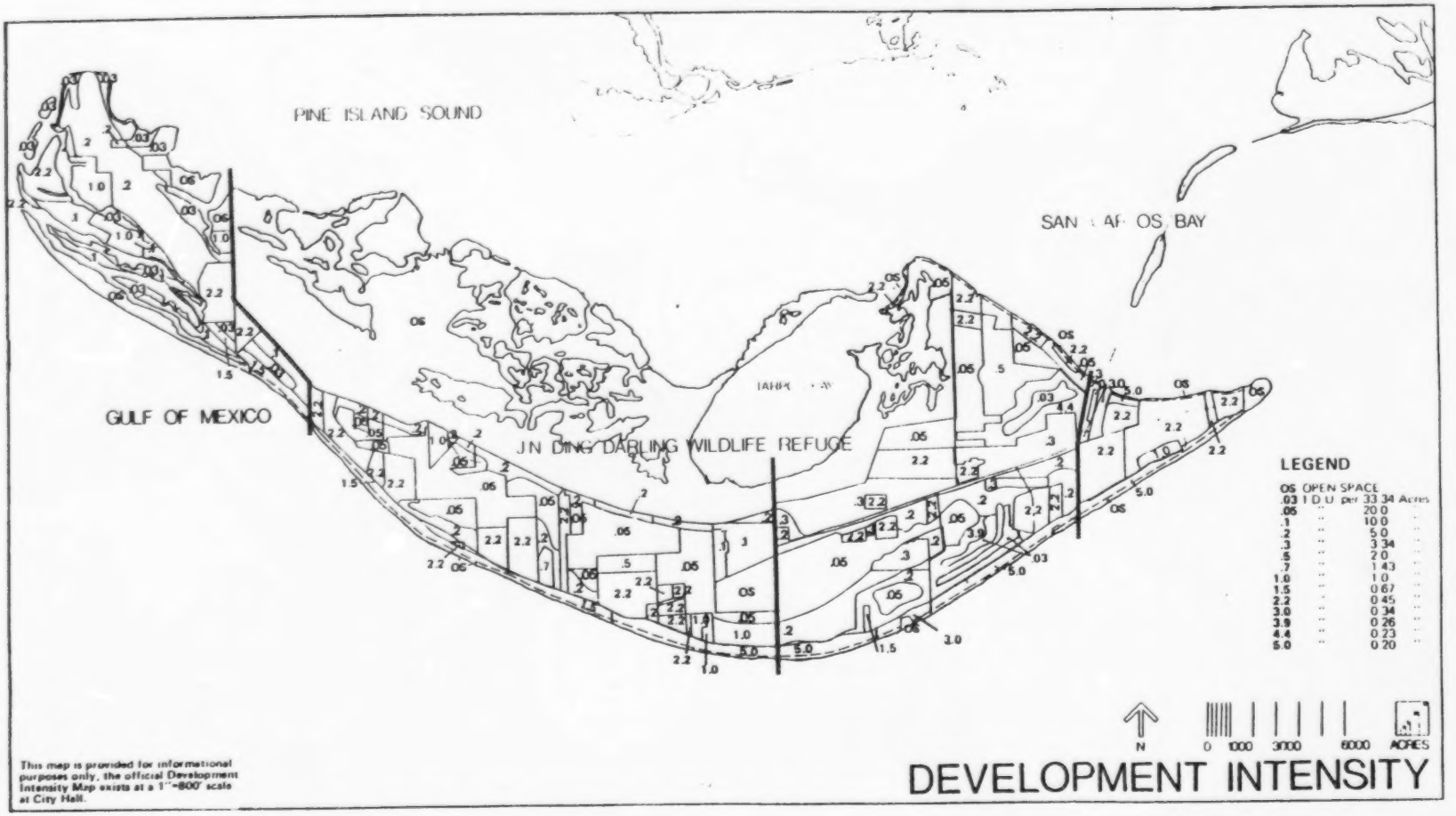
The Functions of Sanibel's Major Ecological Zones As Interpreted By Wallace, McHarg, Roberts and Todd
Source: Clark T., The Sanibel Report, The Conservation Foundation, 1976

FIGURE 3


PINE ISLAND SOUND
SAN CARLOS BAY
TARPON BAY
GULF OF MEXICO
JN DING DARLING WILDLIFE REFUGE
LEGEND
SINGLE FAMILY (AMENDED SEPT 1977)
SINGLE FAMILY, DUPLEX; MULTI-FAMILY, RESORT HOUSING
SINGLE FAMILY, DUPLEX; MULTI-FAMILY
SINGLE FAMILY, DUPLEX
SINGLE FAMILY
COMMERCIAL
RESTRICTED COMMERCIAL
This map is provided for informational purposes only, the official Permitted Use Map exists at a 1"=800' scale at City Hall.
N
0 1000 3000 6000 ACRES
PERMITTED USES

Permitted Uses Recommended For Sanibel Island By the New Comprehensive Plan.
(Source: The City of Sanibel Planning Commission, courtesy of Wallace, McHarg, Roberts, and Todd, planner

FIGURE 4



Dwelling Unit Density Calculated For the City of Sanibel Comprehensive Plan. (Source: The City of Sanibel Planning Commission; courtesy of Wallace, McHarg, Roberts, and Todd, planners).

The figures also provide an excellent overview of the transition from environmental data to the land use plan in the environmental planning process. The scientist initially collects data which is essentially descriptive in nature. Through discussions with planners who are sensitized to scientific information (either through professional training or experience), the data is transferred from a descriptive to a predictive context. The analysis or intermediate phase concludes with the establishment of the land use plan. The planner provides for communication between the scientist on one hand and the client on the other. The product of the inter-communication between data and needs is a land use plan.

The Sanibel Plan emerged out of a long history of political and legal conflict. Initially, this involved political incorporation and separation from Lee County on the mainland. Today the Sanibel Plan is before the Courts with no end in sight.

3. Lake Tahoe Region, States of California and Nevada

The Lake Tahoe Basin covers approximately 327,500 acres of which 37% is Lake Tahoe and 63% is land. Clear blue waters of Lake Tahoe in combination with a mountain, alpine setting make the Lake Tahoe Basin unique in North America. It is also virtually a self-contained landscape unit. Its beauty is fabled, and has attracted many visitors and tourists to vacation resorts and casinos found along the shores. Concern over the impact of casino and recreation development lead to the preparation of environmentally based planning instruments geared to preserving the landscape beauty while providing for development.

Land use regulations exercised in the Lake Tahoe Basin have been developed from a Land Capability Class system developed by Robert G. Bailey for the Forest Service and the Tahoe Regional Planning Agnecy.[49] All lands within the Basin have been designated as either High Hazard, Medium Hazard or Low Hazard and assigned to a seven class land capability system. These designations are based on a level of use each class can tolerate without experiencing permanent erosion damage. Water is seen to be the key to the Lake Tahoe Basin. Land clearing and development can produce profound changes in the drainage characteristics of any area. Sediment volume can increase from 100 tons/sq.mile/yr. on forested land to 300 tons/sq.mile/year for mixed rural land to 500 tons/sq.mile/year for farmland to 10,000 tons/sq.mile/year for light development. Likewise, a six-fold increase in the amount of water which runs off the land can occur during this transition.[50] These changes are accentuated in areas of rugged mountain topography.

Table 2 displays the basic three level Hazard designations and the structure of the land classification. Each Hazard class is divided into the biophysical units which comprise it. The quality of land found in each unit is noted as well as the provisions for lot coverage. 66% of the land is found in the High Hazard Class while 14% is in the Low Hazard Class. While not more than 1% of the High Hazard Lands are to be covered with impervious surfaces, 25 and 30% of the Low Hazard Class may be used. The classification system and the coverage arrangements are intended to minimize water quality impacts from urban development on Lake Tahoe.

TABLE 2: DISTRIBUTION AND ALLOWABLE COVERAGE OF LAND BY LAND CAPABILITY CLASS

Hazard Class	Land Capability Description	Numerical Designation	Quantity of Land By Class (Acres	(%)	Amount Each Class allowed To Be Covered With Impervious Material (%)	(Acres)
High	Lands That Should Remain Natural	1				
	Very Steep mountain slopes	1a				
	Poor natural drainage	1b	152,000	74.1	1	1520.4
	Fragile flora and fauna	1c				
	Steep mountain slopes	2	4,700	2.3	1	47.0
Medium	Lands Permissive to Certain Use					
	Moderately steep mountain slopes with high runoff potential	3.	12,900	6.3	5	645.0
	Moderately steep mountain slopes with low to moderate runoff potential	4	7,050	3.4	20	1410.0
Low	Lands Most Tolerant to Urban Use					
	Gently sloping foothills with high runoff potential	5	16,730	8.1	25	4182.5
	Gently sloping foothills with low runoff potential	6	8,800	4.3	30	2640.0
	Flat valley floors	7	3,030	1.5	30	909.0
			205,250	100.0		11,353.9

Source: Robert G. Bailey, Land-Capability Classification of the Lake Tahoe Basin California-Nevada, US Forest Service and the Tahoe Regional Planning Agency 1974

The Tahoe Regional Planning Agency General Plan (prepared subsequent to the Land Capability Classification of the Lake Tahoe Basin) relied on the concept of land capability and lot coverage developed by Bailey when public lands were zoned. However, much of the land which was built on prior to the Plan was in many ways developed in a manner inconsistent with the Classification System. In addition, there existed many subdivided lots which had not been developed at the date of the Plan. These undeveloped lots were located in areas which also were inconsistent with the land capability system. Subsequently, provision was included in the Plan for the implementing body to provide for variances. Today, considerable concern exists as to whether planning efforts have been successful in dealing with environmental deterioration in the Lake Tahoe Basin.

D SUMMARY

From this review of three environmental land use plans, what can be concluded about the application of land classification techniques to the goal of achieving landscape stability? The following points are put forward to answer this question:

1) In the first portion of this paper, the review of planning and scientific data on separation distances from streams, rivers, lakes and oceans revealed that there is a distance safety factor involved between waste treatment systems and standing water bodies. While the dimensions of the distance varied depending on the waterbody, the pollutant measured, and scientific judgement exercised, planning efforts can rely on the need for such a setback to achieve water quality goals. More important, however, was the coalescence of environmental sensitivities in this setback. Vegetation, within the setback was important in filtering surface drainage to the water body and in preventing erosion and consequent sedimentation. The setback became an important ingredient in wildlife planning as well. Other research has verified the importance of this setback for fisheries and aquatic environment concerns. This grouping of environmental sensitivities in defineable land units establishes the basis for achieving the environmental goal of landscape stability in a land classification.

2) In the second part of the paper, planning and management strategies based on environmental processes were reviewed. Land units were identified based on functions performed within these environmental processes. These units were considered to be physical expressions of these processes which operate throughout the land area under a study. While these processes (i.e. the movement of water on the Eastern Slopes and the Island of Sanibel) were seen to transcend all zones, certain zones exercise key functions in these processes. Maintenance of these functions was seen to imply restrictive land use centres within these land units. In achieving landscape stability, zones based on functions performed were identified and prescribed for appropriate land uses.

3) While land use zones were identified on the basis of performing environmental functions, environmental concerns were not pre-eminent throughout. Lands for use and development were also prescribed. A balance was sought between development, environmental, and social processes within each planning jurisdiction. Each plan's goal was to enable development to occur while remaining within the limits of environmental processes. Balanced development will entail enhancement of both environmental and socio-economic processes. Rather than being at odds, each is dependent on the other.

4) Each of the land use plans reviewed, is based on the assumption that there are environmental limits and that these limits can be treaslated into meaningful land use planning and policy terms. The consequences of limits can be tragic when these are exceeded and no outside relief exits. While limits are considered by some to be overly deterministic, or Malthusian, or subjective, consideration is justified, if only to error on the side of safety.

5) Land capability/suitability maps (the traditional end product of current land classification efforts) can be used as criteria for establishing environmental zones, particularly those zones geared to uses such as agriculture, forestry, etc. These maps are less useful as a basis for defining zones based on environmental functions performed.

6) Biophysical land classification techniques are based on a wide range of environmental data including climate, geology, soils, ground and surface water, vegetation and wildlife. Often, not all these components will be applied in the classification. The units defined usually reflect homogenous physiographic regions. When the process elements of the planning area environment are understood (hydorlogic cycle, nutrient flows etc.) these physiographic uhits can be used as the functional land units of the land use plan. The Sanibel Plan identified several ecological zones which are essentially physiographic land forms. Their significance, however, arises not out of the land capability exhibited, but, rather the function each unit performs.

7) Environmental impact assessment tends to be a design oriented approach. Reliance on the design process solely to achieve environmental goals in a land use plan will mean that any use can compete on a given parcel of land provided mitigating factors can be instituted to reduce environmental impact. Such assessments may not involve an appraisal of the minimum functional requirements of an environmental system. Design involves putting some use to a parcel of land with the least impact. Environmental zoning, on the other hand, involves an assumption of the minimal operating requirements of an environmental system aside from design oriented questions. Reliance on either planning approach solely will, I believe, result in an unbalanced approach to the environment.

E CONCLUSION

At the outset, the question was asked as to how one would reconstitute environmental data in a land classification which has a goal, ecosystem stability. The first step involves the consideration of the planning area landscape in ecosystem terms, that is, as being formed by several environmental processes. Modelling can assist one in understanding these processes. Invariably the planning area can be differentiated into land units on the basis of the functions performed in

identified environmental processes. The most important functional areas become the zones of principal concern in the environmental plan. These units usually can be mapped by examining vegetation patterns, soils distribution, physical morphology and the usual constituents which comprise biophysical land classifications. By considering landscape in terms of functions performed, ecosystem stability can be appropriately dealt with.

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ABOUT THE AUTHOR

George McKibbon is a graduate of the Faculty of Environmental Studies at York University in Toronto. He is principally employed by the Niagara Escarpment Commission as an environmental planning consultant. Mr. McKibbon is also a member of the Canadian Institute of Planners, and the Ontario Society for Environmental Management.

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